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ABSTRACT

The purpose of this study is to examine patterns of implementation of an inquiry-oriented science program for elementary school students. Project SEED (Science for Early Education Development) is a hands-on science education program for elementary school students in grades kindergarten through 5th. Teachers in 20 elementary schools in Pasadena Unified School District (California) who are using Project SEED kits in their classrooms were part of a longitudinal study. The Concerns Based Adoption Model (CBAM) was used to assess the implementation process at the individual teacher level. Teachers were found to reach fairly advanced concerns, as portrayed by a Stages of Concern instrument, early in their implementation efforts while actual use focused on solving mechanical problems such as time management and ways to help students "finish" the lesson. In addition, teachers were shown to have implemented the less demanding aspects of inquiry-oriented science programs while the more demanding aspects remained to be implemented. The paper discusses how teachers can come to use Project SEED or other inquiry-oriented science programs which place a greater emphasis on the conceptual and process of science outcomes. (LZ)

Inquiry-Oriented Science Programs: New Perspectives on the Implementation Process

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Introduction

There has been considerable interest in dramatically improving the teaching of mathematics and science in elementary schools. Impetus for such reforms comes from several related sources. Numerous reports demonstrate the strong link between mathematics and science and the job future of U.S. students (Johnston, 1987). Yet, by several standards, our students have serious deficiencies in mathematics and science. When compared with students from other industrialized nations, our students fare very poorly in mathematics computation and mathematics reasoning (McKnight et al., 1987) and science (Jacobsen et al., 1986). Similarly, the National Assessment of Education Progress (NAEP) in mathematics, "...clearly shows that although most students are reasonably proficient in computational skills the majority do not understand many basic concepts and are unable to apply the skills they have learned in even simple problem-solving situations" (Romberg, 1988, p. 5). The situation is equally serious in science where NAEP data document declines in science achievement (Hueftle et al., 1983) and lack of improvement in higher order reasoning about science (NY Times, 1988).

Impetus for reform also has come from related concerns about equity of educational opportunity for students. Five out of six new entrants to the work force between now and the year 2010 will be either minorities, immigrants or women-- a disturbing problem when considered in light of a school system that Resnick and Resnick (1977) have characterized as a dual track system of "high literacy" and "low literacy" schools. Unfortunately, the "low literacy" schools tend to disproportionally serve ethnic minority students. Sex gender differences in mathematics and science performance also contribute to the nature of the problem facing our schools and society.

A host of national reform reports have provided extensive proposals for the reform of mathematics and science education in public schools. Building on early reports (especially A Nation at Risk and Educating Americans for the 21st Century), extensive reforms proposed for mathematics education have been made. The key reports are: What is Still Fundamental and What is Not (Conference Board of the Mathematical Sciences, 1983a), New Goals of Mathematical Sciences Education (Conference Board for the Mathematical Sciences, 1983b), and School Mathematics: Options for the 1990's (Romberg, 1984). Similarly, in science, excellent proposals for reform have included What Science is Most Worth Knowing? (National Council on Science and Technology Education, 1987) and Educating Our Citizens: The Search for Excellence (Center for National Policy, 1983). The funded proposal for the National Center for Improving Science Education provides an extensive analysis of these proposals and their contribution of current thinking about directions which should be taken (The NETWORK, 1987).

While important conceptual work remains to be done, these reports provide a considerable consensus about the goals, content, and instructional strategies which should be incorporated into contemporary programs of mathematics and science for elementary schools. For example, in mathematics education, the National Council of Teachers of Mathematics has provided a major synthesis of desired curriculum changes (NCTM, 1987; Romberg, 1988) and in science education, the National Science Teachers Association has provided a similar set of proposals found in the Phase I report of Project 2061 (National Council on Science and Technology Education, 1987).

In addition to being comprehensive, these curriculum proposals have considerable research support. An excellent review of the teaching and learning of mathematics is provided by Romberg and Carpenter (1986) and a similar review of research on the teaching of natural sciences is provided by White and Tisher (1986). A more specific review of exemplary science programs for elementary schools points both to the "good news" and the "bad news" about elementary science programs (Bredderman, 1973). The good news is that when inquiry-oriented, activities-based elementary science programs are compared with traditional programs, students in the inquiry/activities programs are significantly better at: a) carrying out the process of science, b) having more positive attitudes about taking more science, and c) retaining more science content. The bad news is that many teachers, even those who participated in the NDEA Institutes of the 1960's, were unable to sustain classroom implementation of the inquiry-oriented programs. Only approximately 20 to 25% of the teachers had successful implementation of these programs (Bredderman, 1973).

From a policy perspective, these previous efforts to improve science education were based on an effective curriculum orientation that simply wasn't implemented despite a considerable policy initiative by the federal government. The national curriculum projects developed sophisticated but inflexible curriculum packages that often didn't fit district curriculum priorities nor other aspects of the policy context such as testing or textbook adoption in the district or state. Moreover, teachers attending the summer institutes needed help in implementing the programs back at their schools. This help was frequently inadequate, or even nonexistent. Moreover, the implementation process ignored the organizational and systemic nature of the reform. Principals, district curriculum leaders, and others failed to understand and support the reform sufficiently-- and the problem was both of will and capacity to do so. Sarason (1982) provides an extensive analysis of the failure of these reforms at the local school and district level.

Other studies also illustrate the difficulties in implementing inquiry-oriented science programs. Loucks and Pratt (1978) found that teachers in an exemplary, district-wide science program had great difficulty in implementing the curriculum despite intensive staff development. Peterson (1989) and Cohen (1990) confirm that implementation problems remain a serious issue in establishing innovative science and math programs in elementary schools.

Recent research by Fullan (1991), Odden (1991), and Huberman and Miles (1984), and Odden and Marsh (1989) supports the view that new approaches to curriculum can be successfully implemented under new conditions. This body of research points to the importance of both organizational and assistance strategies including factors such as:

* Ambitious efforts were better than narrowly focused projects or a change in the entire local structure.

* The specific change processes were more important than the type of change pursued, geographical location or ethnic characteristics of the districts or schools. How it was conducted was more important than what the change was.

* High quality, proven effective programs worked better. Research based programs produced more outcome success than locally created ones.

* Top-down initiation could work. Earlier studies had concluded that only bottom-up initiated change could work.

* Central office support and commitment and knowledge were needed.

* Teacher participation, especially in designi~~ implementation strategies, mattered. Teacher involvement through cross role teams including administrators was important.

* Extensive, intensive, on-going training and classroom specific assistance for learning new instructional strategies was critical. On-going assistance was the sina qua non for effective program implementation.

* Teacher commitment was critical. Few successful change efforts reached advanced stages of implementation unless teacher commitment to the project developed at some time during the process. Up front commitment was not necessary for successful implementation.

Over the last two decades, another line of implementation research has focused on the pattern of implementation associated with individuals undergoing the change process. Hall and Hord (1987) report a body of research using the best known conceptual framework for studying individuals engaged in the change process: the Concerns Based Adoption Model (CBAM). CBAM has used three tools to assess the process of change for individuals:

Stages of Concern (SoC). A conceptual framework of 7 stages of concern about the innovation which teachers tend to evolve through.

Levels of Use (LoU). This conceptual framework has 8 levels of actual use of the innovation by the individual teacher.

Innovation Configuration (IC). This conceptual tool allows for the description of what version of a new curriculum is actually being used by individual teachers.

These tools allow for systematic study of the implementation process as undertaken by individuals.

Statement of the Problem

New curriculum approaches designed to help elementary school students inquire and think conceptually about science have tried to overcome the shortcomings of the NSF-based curriculum approaches of the 1960's. The curriculum is often more flexible and kit-based to focus the substance while also incorporating powerful approaches to instruction. Implementation of these new approaches has attempted to incorporate both systemic and personal strategies that include much of what is known about successful implementation. What is still problematic is whether these new implementation strategies are sufficiently effective to lead individual teachers to use the new curriculum approaches in their classrooms, and whether these approaches (when fully implemented) lead to enhanced student learning. The first issues--the extent and pattern of actual implementation is the immediate concern given the spotty history of success in implementing inquiry-oriented science programs. In this analysis, the concerns, patterns of actual use and versions of the program used are especially important.

Purpose of the Study

The purpose of this study is to examine patterns of implementation of an inquiry-oriented science program for elementary school students. The program to be studied has addressed many of the dilemmas related to weak implementation of NSF-funded efforts in the 1960's. Project SEED (Science for Early Educational Development) is a hands-on science education program for elementary school students in kindergarten through 5th grade. Developed at the California Institute of Technology, the project is currently being implemented in the Pasadena Unified School District under an NSF grant given to Cal Tech and the district. The curriculum is designed to assist students develop the process of science, mostly by posing scientific questions and having children seek the answers through careful observation and analysis of information. For each grade level, four science units in the form of "kits" which have been developed by Cal Tech and Pasadena Unified School District are currently being used in the Pasadena schools. At present, one teacher at each grade (K-5) level across 20 elementary schools in Pasadena is using the science curriculum.

The research questions for the study are:

1. What concerns about Project SEED do teachers express and how do these concerns evolve over time for different cohorts of teachers?

2. What levels of actual use of Project SEED do teachers have, and how do these levels of use evolve over time for different cohorts of teachers?

3. In what ways do teachers vary Project SEED in their classrooms, how do these variations evolve over time, and what reasons do teachers have for these variations?

4. What patterns exist among teachers' concerns, levels of actual use, and program variations, and how do these patterns evolve over time?

5. What factors (teacher characteristics, program implementation factors, etc) are related to changes to the patterns of teacher concerns and use of Project SEED?

Methodology

Data Source. This study focused on teachers in 20 elementary schools in Pasadena Unified School District who are using Project SEED kits in their classrooms. Cohort I was used as a pilot group to test the reliability of data collection instruments. Cohorts IIa, IIb, and IIc were part of the longitudinal study for this report. The sample of teachers (Cohort I) for the spring 1991 data collection was a 50% sample of 66 teachers using Project SEED across 10 pilot elementary schools. Teachers from 7 elementary schools were included. While this sample was not randomly drawn in a strict sense, care was taken to insure that the range of teachers and schools participating in Project SEED were included to join a representative group.

The sample of teachers for the fall 1991 data collection was a sample of 149 (41%) teachers using Project SEED in 20 elementary schools (Cohort IIabc). Cohort IIa comprised 15 teachers from the pilot spring 1991 study, Cohort IIb comprised 21 teachers using Project SEED in the spring of 1991 but who were not part of the spring 1991 study and, Cohort IIc comprised 25 teachers new to Project SEED at the 10 non-pilot elementary schools. This sample represented a random sampling of all 20 schools with an equal distribution of teachers from grade levels K-5. This sample will become the base data source for the longitudinal study.

Of the 61 teachers interviewed, the majority were middle-aged, white females with 20 years teaching experience. Most had taught at their current school sites at the same grade level between 1 and 5 years.

Instrumentation and data collection. Hall and Hord (1987) have summarized three research tools that have been developed to assess the implementation process at the individual teacher level. These tools comprise the Concerns Based Adoption Model (CBAM) developed by Hall and associates over the last decade. In order to establish the extent of implementation over the two year period, teachers were divided into Phase I and Phase II groups and subsequently interviewed and observed using two of the CBAM tools, the LoU and the IC:

> Levels of Use (LoU). This conceptual framework has 8 levels of actual use of the innovation by the individual teacher. The 8 levels are: Non-use, orientation, preparation, mechanical use, routine, refinement, integration, and renewal. These data were be collected using a standardized interview which is tape-recorded for subsequent scoring.

> Innovation Configuration (IC). This conceptual tool allows for the description

of what version of Project SEED is actually being used by individual teachers. Both observation-based and questionnaire-based data was used.

In order to assess the factors necessary for implementation, teachers were interviewed, observed and given an SoC questionnaire, the third tool of the CBAM model:

Stages of Concern (SoC). A conceptual framework of 7 stages of concern about the innovation which teachers tend to evolve through. The stages are: Awareness, informational, personal, management, consequence, collaboration, and refocusing. The questionnaire has 35 Likert-response items.

Extent of Implementation-Pilot Study

Cohort I

SOC Questionnaire. The pilot study helped identify patterns of initial implementation by teachers and helped refine instruments used in the study. Table 1 shows the distribution of teacher SoC scores as measured by the SoC questionnaire.

Table 1
Distribution of SoC Scores
For Participating Teachers Cohort I
(N=28)

Stage of Concern	Number of Teachers
SoC 2: Personal Concerns	2
SoC 3: Management Concerns	0
SoC 4: Consequence Concerns	9
SoC 5: Collaboration Concerns	17

It was surprising to find the dominant stage for teachers on the SoC questionnaire was Stage 5: Collaboration concerns. However, it was noted that teacher's Collaboration Concerns were centered around how to carry out the project, or in fact, Management Concerns. Moreover, the SoC interview revealed that many teachers were highly dependent on the project staff in carrying out the project in their classrooms.

Levels of Use (LoU). Teachers were observed in their use of Project SEED in their classrooms and given the research version of the LoU interview. Table 2 shows the actual pattern of use of Project SEED.

Table 2
Distribution of LoU Scores
For Participating Teachers Cohort I
(N=28)

LoU III: Mechanical Use	17
LoU IVa: Routine Use	6
LoU IVb: Refinement	2
LoU V: Integration	1
Unable to Measure	2

Most teachers were understandably at a (LoU III) Mechanical Use in relation to the projects. Teachers at this level often express difficulties in organizing materials and their time for instruction as well as beginning and concluding the lesson. Teachers are often surprised at the way lessons turn out and are on a short time frame in their ability to plan or anticipate what is going to happen.

Some teachers who had achieved a higher level of classroom use (LoU IVa), settling into a stable pattern did not plan to make any further changes in the year to come. However, one may think of this apparent stagnancy as a "plateau" at which these teachers are still not necessarily using the project at a high level of quality. For example, one teacher responded:

> Last year I did not pace myself very well. This year, however,
> I was able to complete all the activities in the kit. #4802

One expects to see a spiraling pattern of use, one in which the teacher plateaus for a period of time and then spirals to the next level of use through experience of use. For example, the teacher may complete all kit lessons this year, but next year, the quality of each lesson will improve.

Innovation Configuration (IC). Figure 1 (in the appendix) portrays the key components of Project SEED and the variations in how these components might be manifested in the classrooms. Part of the interview with each teacher focused on how the teacher was actually doing parts of the program. Because of the time limitations in the interview and classroom visits, the data reveal general patterns of use rather than extensive detail for each teacher.

Patterns of use, or the Innovation Configuration among Cohort I teachers showed an even split between those "just getting started" and those in "successful" patterns of use during the spring 1991 study. Figure 2 is a summary of Cohort I teacher progress for their use of Project SEED as examined in light of the Innovation Configuration. In general, teachers are fairly evenly split between "just getting started" and "successful" patterns of use at this time.

Figure 2

Innovation Configuration of Participating Teachers

Key Component	Observations
Use of the Kit	Teachers were evenly split between just getting started and successful implementation.
Adaption of Use	Most teachers had adapted Project Seed to their classrooms. Examples of adaption include adding science materials from other sources, making material easier to use for LEP students, and providing additional skills practice wl...e it was needed.
Independence of Use	Most teachers were quite independent on the Project SEED staff in carrying out the program in their classrooms
Time Allocation	Teachers were split between just getting started and successful use.
Purpose of the Lesson	Many teachers could describe Project SEED as a set of activities found in the kits, but seemed to have difficulty understanding the overall objectives themselves or communicating these objectives to students.
Curriculum Connections	Teachers in the lower grades were more involved in connecting Project SEED to other parts of the curriculum-some were very good at doing this.
Introduction of Lesson	Many teachers did this part very well, in part because the kits and the project staff provided good examples of how to launch the lesson. Teachers were asking good questions at the beginning of the lesson.
Teacher Role	Behavior management was a frequent problem as were techniques for engaging students. Teachers were monitoring and asking questions but often had difficulty engaging most of the class in real inquiry.
Lesson Closure	Many teachers seemed to have difficulty bringing conceptual closure to the lesson. Most could handle closure on a management level fairly well.

Grouping/Student Role (appropriate to developmental level)	Students were working in groups as required by the kits. Most groups were heterogeneously organized; some teachers modified the groups over time to allow natural leaders to emerge.
Student Logs (appropriate to developmental level)	Many teachers used creative data collection appropriate to the developmental level of the students. Students were doing lots of data recording but were less able to reflect on the information.
Evaluation/Assessment	Some teachers looked at the student journals; most showed active concern about how students were engaged. Few teachers had a strong focus on the adequacy of student learning and few adjusted their lessons to enhance student learning of key objectives(many teachers adjusted their lessons to help students complete the activities).

Patterns of Implementation Over Time

Stages of Concern. Table 3 portrays the SoC results for the fall 1991 data collection. Of the teachers in Cohort IIa, 60% showed a change in their SoC stage from spring 1991. The most common change was from SoC stage V to SoC stage IV as well as the reverse, from SoC stage IV to SoC stage V. 33.3% showed no change in SoC stage from the spring to fall data collection and one survey was not returned.

Table 3
Distribution of SoC Scores
For Participating Teachers Fall 1991

Stage of Concern	Numbers of Teachers IIa N=15	IIb N=23	IIc N=23
SoC 2: Personal Concerns	0 (0%)	0 (0%)	1 (4%)

SoC 3: Management Concerns	3 (20%)	3 (13%)	0 (0%)
SoC 4: Consequence Concerns	6 (40%)	10 (43%)	15 (65%)
SoC 5: Collaboration Concerns	5 (33%)	6 (26%)	6 (26%)
SoC 6: Refocusing Concerns	0 (0%)	1 (4%)	0 (0%)
No Response	1 (6%)	3 (13%)	1 (4%)

The major difference between the spring 1991 pilot teachers and fall 1991 Cohort IIc teachers was in the dominant SoC stage, Stage 5: Collaboration for the pilot group and Stage 4: Consequence Concerns for Cohort IIc. However, teachers in Cohort IIc scored Stage 5: Collaboration second highest. Further, it is interesting to note that there were no Stage 3: Management Concerns among teachers in Cohort IIc nor were there for the pilot group.

Cohort IIb shows more similar stage score comparisons to Cohort IIa. It is reasonable to consider that teachers at the same school share information about Project SEED that the newer schools do not have access to. Hence, Cohort IIb teachers may have preconceived concerns about Project SEED, especially related to Management and Consequence Concerns.

Those teachers scoring SoC Stage V were further questioned regarding the type of collaboration that took place among SEED teachers. Most teachers stated that the nature of their collaboration centered around management concerns as it did in the pilot study. Most teachers responded that there was no time "just to get together and talk" due to the nature of their work day and scheduling differences. However, two teacher were able to conduct several crayfish experiments between themselves and their classrooms (Cohort IIa and Cohort IIb teachers).

The SoC interview revealed that few of the Cohort IIa teachers were relying on the Project staff; in fact, they were not visited by Project staff unless the teacher requested assistance. The field staff members spent their time with Cohort IIb and IIc teachers. Cohort IIc teachers showed the greatest need for assistance:

> Yvonne did a lesson for me on liquids, the glycerine and alcohol one that I was unclear on. (Case # 7508).
>
> or
>
> I still try to do it even when she doesn't come. (Case # 3677).

Levels of Use (LoU). Teachers were observed in their use of Project Seed in their classrooms and given the identical research version of the LoU interview as was given in the pilot study. Table 4 shows the results for Cohorts IIa, IIb, and IIc for the fall 1991 study.

Table 4

Distribution of LoU Scores
For Participating Teachers Fall 1991

Level of Use	Number of Teachers IIa N=15	IIb N=23	IIc N=23
LoU III: Mechanical Use	4 (26%)	8 (35%)	14 (60%)
LoU IVa: Routine Use	3 (20%)	9 (39%)	5 (22%)
LoU IVb: Refinement	7 (46%)	5 (22%)	4 (17%)

LoU V: Integration	1 (6%)	1 (4%)	0 (0%)
Unable to Measure	0	0	0

53% of Cohort IIa teachers showed no change in the level of use of Project Seed. The majority of teachers in Cohort IIa (26%) have remained at (LoU III) Mechanical Use, not progressing beyond organizing and managing the kits. No teacher reached (LoU V) Integration and only two progressed from (LoU IVa) Routine Use to (LoU IVb) Refinement. One teacher progressed from (LoU III) Mechanical Use to (LoU IVb) Refinement.

Teachers in Cohort IIb show a different pattern of levels of use than do the other two Cohorts. Only 35% showed (LoU III) Mechanical Use, whereas 39% showed (LoU IVa) Routine Use. Again, it is relevant to assume communication between Cohort IIa and Cohort IIb teachers and, perhaps, teachers in Cohort IIb are learning from their colleagues.

Most teachers in Cohort IIc were at a (LoU III) Mechanical Use in relation to the use of Project SEED. Teachers in Cohort IIc were experiencing the use of the kits for the first time in their classroom settings. Naturally, the first time the kits were used, teacher focus was on organization of materials and time, as well as lesson presentation.

One teacher in Cohort IIc at the Mechanical Use (LoU III) responded:

> I was scared to death to start it, it sat there for two weeks before I used it. (Case #0011)

Another teacher was not as positive with her use of the Project SEED kits:

> I prefer not to do it at all. They come in and model but its too much to know. It really interrupts everything I am doing. (Case #8576)

Teachers in Cohort IIc and in the pilot study showed (LoU III) Mechanical Use as the dominant level (60%). It was interesting to note that only 7% of the pilot study teachers were at (LoU IVb) Refinement; whereas, 22% of Cohort IIc had reached this level of use. It is possible that the level of assistance offered Cohort IIc teachers is different than the assistance offered teachers in the pilot study; hence, Cohort IIc teachers have been able to implement Project SEED with more innovation than in the pilot group.

Although the majority of teachers across Cohorts were focused on the relevance of Project SEED for their students, they engaged in little evaluation or teaching style change in order to increase student outcomes. Project SEED does not contain materials for an evaluation component and hence, teachers in the study determined student learning through teacher observation, student questioning, student responses and journals. Journals were kept by most students; however, they were more non-graded recording books than evaluation or assessment tools. Several teachers expressed concerns that they had no means of evaluating student learning. Only one teacher quizzed students on kit learning (Case #5797). When questioned, "How do you know students are learning?", the most common response was: "I don't know that they are".

Relationship of SoC, LoU, and IC. Figure 1 (in the appendix) portrays the key components of Project SEED and the variations in how these components might be manifested in teacher classrooms. Patterns of use, or the Innovation Configuration, was developed for each of the 61 teachers in the study and then compared to the level of use (LoU) of each teacher. Rather than display counts for the Innovation Configuration alone, Table 5 displays the comparison between key components of Project SEED and the teacher's level of use (LoU).

Table 5

A Comparison of Teacher Innovation Configuration and LoU III

N=21

Key Components	Successful	Moderately Successful	Just Getting Started
Use of the Kit	0 (0%)	15 (71%)	6 (29%)
Adaption of Use	3 (14%)	15 (71%)	3 (14%)
Independence of Use	2 (9%)	15 (71%)	4 (19%)
Time Allocation	0 (0%)	7 (33)	14 (66%)
Purpose of the Lesson	1 (5%)	6 (29%)	14 (66%)
Curriculum Connection	1 (5%)	8 (38%)	12 (57%)
Introduction of Lesson	0 (0%)	18 (85%)	3 (14%)
Teacher Role	0 (0%)	16 (76%)	5 (24%)
Lesson Closure	0 (0%)	18 (85%)	3 (14%)
Grouping/Student Role(appropriate to developmental level)	4 (19%)	14 (66%)	3 (14%)
Student Logs(appropriate to developmental level	0 (0%)	15 (71%)	6 (29%)

Evaluation/Assessment	0 (0%)	14 (66%)	7 (33%)

57% of (LoU III) Mechanical Use scores belonged to teachers in Cohort IIc, 38% to Cohort IIb, and 19% to Cohort IIa. The majority of teachers showed moderately successful patterns of use. However, a large majority of teachers showed just getting started patterns of use with respect to three key components: time allocation, purpose of the lesson and curriculum connections. In essence, teachers did not devote enough time to science nor were they able to adapt the kit to different blocks of time availability. Further, teachers and students performed the experiments with little connection to the overall purpose of the lesson and had difficulty integrating the various science lessons with other curriculum areas.

Table 6 displays the comparison between teacher Innovation Configurations and (LoU IVa) Routine Use.

Table 6

A Comparison of Teacher Innovation Configuration and LoU IVa

N=17

Key Components	Successful	Moderately Successful	Just Getting Started
Use of the Kit	0 (0%)	17 (100%)	0 (0%)
Adaption of Use	8 (47%)	8 (47%)	1 (6%)
Independence of Use	11 (65%)	6 (35%)	0 (0%)
Time Allocation	2 (12%)	14 (82%)	1 (6%)

Purpose of the Lesson	1 (6%)	15 (88%)	1 (6%)
Curriculum Connection	4 (23%)	13 (76%)	0 (0%)
Introduction of Lesson	1 (6%)	16 (94%)	0 (0%)
Teacher Role	0 (0%)	17 (100%)	0 (0%)
Lesson Closure	1 (6%)	16 (94%)	0 (0%)
Grouping/Student Role (appropriate to developmental level)	11 (65%)	6 (35%)	0 (0%)
Student Logs (appropriate to developmental level	0 (0%)	17 (100%)	0 (0%)
Evaluation/Assessment	2 (12%)	15 (88%)	0 (0%)

53% of the (LoU) Routine Use group belonged to Cohort IIb, 29% to Cohort IIc, and 18% to Cohort IIa. Comparatively fewer teachers with (LoU IVa) Routine scores showed just getting started patterns of use than did those teachers with (LoU III) Mechanical Use scores. Teachers in this group also showed patterns of use which incorporated greater time allocation, greater understanding of the purpose of the lessons, greater curriculum connections. These teachers were more independent of project staff yet were still making little use of teachable moments.

Table 7 displays teacher Innovation Configurations and teacher level of use (LoU IVb) Refinement.

Table 7

A Comparison of Teacher Innovation Configuration and LoU IVb
(N=16)

Key Components	Successful	Moderately Successful	Just Getting Started
Use of the Kit	1 (6%)	15 (94%)	0 (0%)
Adaption of Use	12 (75%)	4 (25%)	0 (0%)
Independence of Use	14 (87%)	2 (12%)	0 (0%)
Time Allocation	8 (50%)	7 (44%)	1 (6%)
Purpose of the Lesson	2 (12%)	14 (87%)	0 (0%)
Curriculum Connection	1 (6%)	15 (94%)	0 (0%)
Introduction of Lesson	5 (31)	11 (69)	0 (0%)
Teacher Role	2 (12%)	14 (87%)	0 (0%)
Lesson Closure	3 (18%)	13 (62%)	0 (0%)
Grouping/Student Role (appropriate to developmental level)	15 (94%)	1 (6%)	0 (0%)
Student Logs (appropriate to developmental level	1 (6%)	15 (94%)	0 (0%)
Evaluation/Assessment	2 (12%)	14 (87%)	0 (0%)

44% of (LoU IVb) Refinement scores belonged to teachers in Cohort IIa, 31% to Cohort IIb, and 25% to Cohort IIc. Only one teacher at (LoU IVb) Refinement showed a just getting started pattern of use for time allocation. The majority of teachers showed moderately successful to successful patterns of use, as compared to teachers at (Lou IVa) Routine Use or (LoU III) Mechanical Use.

Teachers in this group had made more adjustments to fit the kits to the needs of their students, were better able to ask questions, model and use teachable moments, and were better than teachers at (LoU III) Mechanical Use or (LoU IVa) Routine Use in utilizing student groups.

In summary, implementation of Project SEED in teacher classrooms was viewed through three lenses: (1). Stages of Concern, (2). Levels of Use and (3). Innovation Configuration. The Stages of Concern survey provided a wide angle view of implementation. Teachers all scored very highly on the questionnaire, leading one to believe that teachers were focused on the impact of Project SEED on their students, the relevance of Project SEED for students, and evaluation of student outcomes. Further, the Stages of Concern results indicated a focus on coordination and cooperation with others regarding the use of Project SEED. However, Levels of Use results became a more narrowed angle view of implementation, shedding a more focused description on the process.

The Levels of Use interview indicated that many teachers, were in fact, having Management Concerns about the use of Project SEED in their classrooms. Moreover, 26% of the teachers using SEED for two years remained at the Mechanical Use level. 60% of teachers at the new schools using Project SEED for the first time were also displaying a need to master the tasks required to use Project SEED rather than focusing on improving Project SEED for the sake of student outcomes.

Although many teachers did reach a level of use in which they began modifying Project

SEED for their particular students, most modifications were simply additions of books or other materials or deletions of activities. Others equated student outcomes with student engagement, as one teacher responded:

> I am not sure they are learning, at least they are not all spaced out looking out the window. (Case #1374)

Although Levels of Use interviews provide a more focused, descriptive view of the implementation process, the teacher Innovation Configuration or pattern of use lens provides the most detailed, focused view of implementation in the classroom. The key components of Project SEED were viewed through teacher observation and interview. The majority of teachers showed a pattern of use which did not reach a successful level of implementation of all key components. The key components of Project SEED that teachers were least successful at were those factors which related to the teacher's understanding of science and his her ability to inquire at deeper levels of understanding. For example, one teacher responded:

> I think teachers have to be more comfortable with the subject. I have a bilingual class and I did not have the cards in Spanish. I wonder if I am doing a good job because I don't know science in Spanish. If I had a science background, I could have described what density really was. I translated it though. (Case #2404)

or

> It's good but I need more of a background, I don't give the answers because I need more science background. (Case #7307).

Teachers were able to conduct the science exercises but were unable to explain what the results meant, why they were doing them, or how they connected to other aspects of the kits or curriculum. One teacher followed the structures kit building the plastic straw structure models with students. The teacher then had students bring in other types of structures such as tepees, bird's nests, and bee hives. The students and teacher commented that they were all structures but they failed to discuss the similarities and differences of structures as well as how they related to the assignment they had just completed (Case #1567). The teacher could not connect force, angles, or materials used as important in architectural design.

Patterns of Implementation: Conclusions and Discussion

These findings lead to two main conclusions:

1. Teachers' concerns (SoC's) about inquiry-oriented science peak early in the implementation process around Consequence and Collaboration Concerns while actual use of inquiry-oriented science (LoU's) remain at Mechanical Use over an extended period of time.

2. An Innovation Configuration shows that teachers have implemented the less demanding aspects of inquiry-oriented science while the more demanding aspects remain to be implemented.

Teachers reached fairly advanced concerns, as portrayed by the Stages of Concern instrument, early in their implementation efforts while actual use focused on solving mechanical problems of use such as time management and ways to help students "finish" the lesson. For teachers, finishing the lesson and having urban students engaged in the lesson's activities was the goal. In a parallel way, the Innovation Configuration-based analysis showed that teachers had implemented the less demanding aspects of inquiry-oriented science programs while the more demanding aspects remained to be implemented. Using this analysis, the purposes of the lesson were lesson completion and student engagement in activity rather than grasping key concepts in science or metacognitive understanding of the process of science. Similarly, lesson introduction became motivation to doing the activity rather than also focusing on an understanding of its learning outcome, and students' reflective journals were well done when students wrote "something" rather than showed an understanding of the underlying purpose of the lesson.

The focus of teacher concerns and actual use of inquiry science suggests that teachers implement these efforts in several cycles: early implementation focusing on lesson completion and student engagement followed by a cycle (yet to be experienced by most of the teachers) focusing on student outcomes characterized by understanding of science concepts and the process of science. This view of cycles in the focus of teacher's concerns and use of inquiry science leads to two observations. The first is about the instrumentation used in the study. In the Stages of Concern conceptual framework, no operational distinction is made between student engagement and student outcomes--both are coded Stage 4: Consequence Concerns. Consequently, the key distinction between engagement and outcome which appears so vital for our analysis of the teachers and their implementation patterns becomes difficult using the CBAM framework because this distinction is blurred when both engagement and consequence are combined into one category: consequence concerns.

Similarly, CBAM treats Collaboration Concerns as a distinct category of concerns that follows Consequence Concerns in a linear progression. Instead, we found that collaboration concerns are important but that these concerns could be linked to management or consequence (engagement) concerns for our teachers. In short, we want to modify the CBAM instruments/analysis so that: a) the two types of consequence concerns are distinguished and b) collaboration is treated as a separate issue from the management/consequence progression.

Our second observation pertains to how teachers could come to use Project SEED, or other inquiry-oriented science programs, with a greater emphasis on the conceptual and process of science outcomes described above. To date, leaders of Project SEED in the district have been able to establish:

- o A kit-based curriculum, covering grades K-5, with student engagement and reflection activities. The kits have been made easy to use--the district has worked hard on the coordination of the materials so that logistics almost always work smoothly.

- o Teacher expectations and obligation that the kits will be used, and at least moderate teacher motivation to use the kits.

Teachers praised the materials available to them in Project SEED. Having been carefully prepared, the kits typically contained all the material needed to conduct the unit. When materials were missing or needed replacement, materials were made available with a very quick turnaround. The extensive effort of the Project SEED staff had been appreciated by the participating teachers.

The summer and mid-year workshops were seen as extensive and very helpful, especially given the newness of this approach to science. Teachers appreciated the chance to work directly with the kits. The on-site assistance of teachers had been very helpful. All but one of the teachers praised the assistance; the remaining teacher was concerned that the help was evaluative and judgmental in nature. Many teachers were quite dependent on the assistance in carrying out Project SEED in their classrooms.

To accomplish this level of teacher use, Project SEED leaders have used several strategies:

1. Linkage of the project to district line authority and coordination strategies. District and project leaders meet with site administrators to coordinate and pressure teacher use. The district resource center coordinates the extensive logistical requirements of Project SEED with considerable success.

2. District mentor teachers (who are deeply steeped in the Project SEED approach) provide assistance on a weekly basis to all the schools. Teachers in their first year of use of Project SEED have weekly visits to their classroom by one of the mentors--the visits focus on modelling, coaching observation and discussion.

3. Summer institutes and periodic workshops during the school year help prepare teachers to use the next set of kits.

To date, the assistance has focused on what teachers needed immediately to use the kits; the assistance has not focused on two vital other issues with any power: an understanding of the deep science concepts underlying the kits and an understanding of the constructivist knowledge/instructional strategies that would help students create this level of understanding.

The project leaders are wrestling an issue familiar to all of us--how to build this deeper understanding among teachers and help them use this understanding in their classrooms. Two strategies appear promising. First, using the summer institutes for teachers who have completed their first year of use of the materials to build a deeper level of understanding of both concepts and instruction. This deep understanding would then become the focus of mentor/teacher and teacher/teacher engagement during the next school year. Second, engaging teachers in examining students' construction of knowledge as part of the research being carried out on the project.

What is unlikely is that teachers like these urban teachers could have developed this deep understanding in the early stages of their individual implementation efforts. As the CBAM framework reminds us, teachers must first address personal and management needs before the several levels of consequence concerns are important to them.